Designing interaction, voice, and inclusion in AAC research

Pullin, Graham; Treviranus, Jutta; Patel, Rupal; Higginbotham, Jeff

Published in:
Augmentative and Alternative Communication

DOI:
10.1080/07434618.2017.1342690

Publication date:
2017

Document Version
Peer reviewed version

Designing Interaction, Voice, and Inclusion in AAC Research

Graham Pullin

University of Dundee

Jutta Treviranus

OCAD University

Rupal Patel

Northeastern University

VocaliD

Jeff Higginbotham

University at Buffalo

Author Note

Graham Pullin, Duncan of Jordanstone College of Art and Design, University of Dundee; Jutta Treviranus, Inclusive Design Research Centre, OCAD University; Rupal Patel, Department of Communication Sciences and Disorders, Northeastern University, and VocaliD; Jeff Higginbotham, Department of Communicative Disorders and Sciences, University at Buffalo.

Rupal Patel has a financial relationship relevant to the content of this submission. She is the Founder and CEO of VocaliD. The other authors report no conflicts of interest.

Correspondence concerning this article should be addressed to Graham Pullin, DJCAD, University of Dundee, Dundee DD1 4HT, Scotland, United Kingdom. Email: g.pullin@dundee.ac.uk

This is an Accepted Manuscript of an article published by Taylor & Francis in *Augmentative and Alternative Communication* on 4 July 2017, available online: http://www.tandfonline.com/10.1080/07434618.2017.1342690

Abstract

The ISAAC 2016 Research Symposium included a Design Stream that examined timely issues across augmentative and alternative communication (AAC), framed in terms of designing interaction, designing voice, and designing inclusion. Each is a complex term with multiple meanings; together they represent challenging yet important frontiers of AAC research. The Design Stream was conceived by the four authors, researchers who have been exploring AAC and disability-related design throughout their careers, brought together by a shared conviction that designing for communication implies more than ensuring access to words and utterances. Each of these presenters came to AAC from a different background: interaction design, inclusive design, speech science, and social science. The resulting discussion among 24 symposium participants included controversies about the role of technology, tensions about independence and interdependence, and a provocation about taste. The paper concludes by proposing new directions for AAC research: (a) new interdisciplinary research could combine scientific and design research methods, as distant yet complementary as microanalysis and interaction design; (b) new research tools could seed accessible and engaging contextual research into voice within a social model of disability; and (c) new open research networks could support inclusive, international and interdisciplinary research.

Keywords: Talk-in-interaction; Interaction design; Speech-generating devices; Vocal identity; Inclusive design; Participatory design

Designing Interaction, Voice, and Inclusion in AAC Research

The Design Stream of the ISAAC 2016 Research Symposium was led by four authors, researchers Jeff Higginbotham, Rupal Patel, Jutta Treviranus, and Graham Pullin, who have been exploring AAC and disability-related design throughout their careers. Each came to AAC from a different background: from social science, speech science, inclusive design, and interaction design. What brought them together is a shared conviction that designing for communication implies more than ensuring access to words and utterances. There are bigger issues at stake in terms of interpersonal interaction, personal voice, and social inclusion. These issues imply and demand new directions for future AAC research.

The workshop participants were Areej Alasseri, Eryn Biddiscombe, Gina Capri, Shakila Dada, Radici Elena, Tina Fagerström, Michelle Gutmann, Gillian Hazell, Shannon Hennig, Mascha Legel, Kathy Look Howery, Ellyn McNamara, Kirsi Neuvonen, Lindsey Ogle, Ann Christine Olsson, Bitte Rydeman, Irina Savolainen, Gerna Scholte, Darryl Sellwood, Sofia Strömberg, Bára Theodórsdóttir, Kendra Thouless, Kerstin Tönsing, and Tan Xuet Ying. Sellwood is a person who uses AAC and was a particularly active participant.

The workshop was structured around three presentations, each by one of the authors, each followed by a dialogue with the first author, Pullin, in order to explore overlaps and even tensions. These dialogues opened out further into group exercises and discussions that included all workshop participants, ending in an open discussion. Look Howery, Hennig, and Scholte then presented a summary of the discussions to the closing plenary session of the research symposium.

The Complexity of Interaction, Voice, and Inclusion

There were three strands to the workshop: Designing Interaction, Designing Voice, and Designing Inclusion. Each of these three terms has multiple meanings, and not just to people from different disciplines as befits such interdisciplinary issues. We believe that this ambiguity reflects a necessary complexity, which is why these are such challenging but important frontiers of AAC research.

Exploring Designing Interaction

Studying Talk-in-Interaction

In the first presentation of the Design Stream, final author Higginbotham explored the implications of the method of *microanalysis* to the design process. Microanalysis refers to the moment-by-moment examination of the interactions between people talking and using AAC in everyday communication also referred to as *talk-in-interaction*. As shown in Figure 1, such work involves recording and studying video of talk-in-interaction (Higginbotham & Engelke, 2013; Ochs, 1979; Ochs, Graesch, Mittman, Bradbury, & Repetti, 2005). Repeated viewing of this video, often slowed down or replayed frame-by-frame, can illuminate interactions so rapid or so subtle as to otherwise escape an observer. It also requires the use of multiple cameras to capture simultaneous views of both the participants and the device being used, so as to observe all of these at once and examine the precise relationships between their interactions.

Insert Figure 1 About Here

A primary finding in the talk-in-interaction literature is that during conversation, participants emergently co-design their own interactions based on role, medium, purpose, and context (Clark, 1996; Clark & Brennen, 1991; Clarke & Bloch, 2013; Goodwin, 1979, 2003, 2007; Higginbotham & Caves, 2002; Higginbotham, Fulcher, & Seale, 2016; Wilkinson, Bloch,

& Clarke, 2011). Higginbotham and colleagues' work shows that participants interact with, through, around, and against the technology available to them, in order to accomplish socially engaged interaction. There is a strong preference for augmented speakers and their partners to communicate without delay, usually through voice and gesture (Higginbotham et al., 2016; Higginbotham & Wilkins, 1999). With increasing delays between linguistic expressions, participants begin to make accommodations in their interactions, such as scaffolding, yes/no questions, or guessing. Delays in utterance compositions that extend beyond a few seconds increase the likelihood for partner disattention, frustration, and misunderstanding, which in turn contribute to presumptions of incompetence, stigma, and social isolation (Robillard, 1999, 2006).

Any AAC system can play both a facilitative and impeding role in the interaction. The paradox of designing interactions is that much of the design and manufacture of AAC devices embraces a signal and content-transmission approach largely influenced by information theory and the sender-receiver model of communication (Higginbotham et al., 2016; Monk, 2008; Shannon, 1948). Terms like speech-generating device and voice output communication aid emphasize the speech and content delivery capacities of AAC technologies. With few exceptions, however -- such as Lightwriter™ [2] (which includes a second text display for the conversational partner to view) and InterAACt™ [3] -- commercial AAC systems rarely explicitly facilitate social interaction and engagement. Indeed, the task of developing richer, more complex interpersonal interactions seem to be delegated to the users of AAC systems. Conversational partners co-design their own interactions through improvisation, to better suit their particular needs and circumstances. Frequently a device is used by both parties to conduct a conversation, and in ways not intended by the manufacturer, subverting its intended design. For example, Higginbotham has observed a person using the eye-tracking window--included in the device only

for calibration purposes--to display gestured eye movements to their communication partner. Documenting such technical impediments to competent interactions, as well as the adaptations made by the interactants in their quest to stay in time, could provide important insights for designing interactions with the next generation of AAC systems.

Practicing Interaction Design

The term *interaction design* (Moggridge, 2006) also refers to the domain of an interdisciplinary design practice. One of its founders, Gillian Crampton Smith, offers the following definition:

> Interaction design is the design of the interaction between people and devices, systems or services. This interaction usually involves the 'new technologies' of computing and communications. But interaction design remains a creative activity - like architectural, graphic or product design. It concerns the social value and cultural meaning of what is designed, as well as its functional efficiency and aesthetic appeal. (Crampton Smith & Tabor, 2007)

Crampton Smith is making a distinction between the art school-led culture of interaction design and the computer science-led field of human computer interaction (HCI). So it is unfortunate that interaction design is still conspicuous by its absence in most AAC design, a notable exception being the Tango!™ [4] on which interaction designers and industrial designers were engaged alongside AAC experts (Pullin, 2009). Yet art school sensibilities and methodologies could make a valuable contribution to AAC research (Cook, 2013; Pullin, 2013).

Because interaction design emphasizes people's experience of interaction, a core method is that of *experience prototyping* (Buchenau & Fulton Suri, 2000). Prototypes often consist of technologically simple devices to simulate more complex technology platforms, or a so-called

"Wizard of Oz prototype" in which a researcher simulates system responses unseen, while a participant engages with a prototype that appears to be working (Martin & Hanington, 2012). In experience prototyping, the distractions of everyday life are a part of the overall experience. This is a research issue because it is the antithesis of removing such complexities in order to conduct controlled experiments.

Another art school methodology is *critical design*, defined by Anthony Dunne and Fiona Raby (Dunne & Raby, 2001) as design that asks carefully crafted questions rather than provides answers and proposes solutions. In other words, critical design is a research methodology, a mode of inquiry (IDEO, 2001; Pullin, 2013). Critical design has been employed to examine wireless surveillance, genetic engineering, and energy policy. Although critical design is rarely applied in disability-related design (Pullin, 2009), in the case of the project Six Speaking Chairs it provoked discussion of tone of voice in AAC (Pullin & Cook, 2010).

The Complexity of Designing Interaction

AAC often combines two different forms of interaction where a device is involved: interaction between a person who uses AAC and their device (i.e., its user interface) and interaction between conversational partners. These two interactions are intertwined and a method such as microanalysis is required to study their interactions with each other. And interaction design is the design discipline which would be best placed to bring a holistic view to these digital, physical, and/or personal interactions, whether redesigning superficially simple word and letter boards or speech-generating devices. This presents both an opportunity for AAC research and a challenge, as the various disciplines may be complementary but are culturally distant and therefore not commonly (if ever) combined. The scientific methodology of microanalysis contrasts with the art school methodology of interaction design. Conventionally, the former

would provide research to inform practice in the latter, so-called research-led design. However, design-led research, or "research through design" (Frayling, 1994, p. 5), could also be invaluable in unlocking these complexities.

Exploring Designing Voice

Producing Personalized Voices

It is recognized that speech-generating devices need a choice of voices. Identical voices can compromise personal identity, social interaction, and interpersonal relationships (Engelke, 2013; Higginbotham, 2010; Mills, Bunnell, & Patel, 2014; McGettigan, 2015). This is satirized in the film Voice By Choice in which three people who use AAC go speed dating using identical voices (Newell & Ridley, 2012). Historically, synthesized voices were seen as a given, and the field of AAC was expected to wait for Nuance™ [5], Acapela™ [6], and others to release technology developed for mainstream markets. Dedicated AAC devices have relied on commercially available speech synthesis platforms that offer only a few voices of variable quality for each gender and which only recently have begun to include age-specific voices for children rather than adults. The heterogeneity of abilities among people in the AAC community is accepted, and, with a greater emphasis on a social model of disability, the augmented speaker is increasingly recognized in terms that are outside their disability (Patel & Threats, 2016). And yet, individualized, personalized solutions to synthetic voices are only just emerging, in part due to the adoption of Apple's iPad™ [7] and other platforms that have revolutionized the technical landscape, blurring mainstream and assistive technologies. AAC is at the forefront of this new research.

Third author Patel described the development of one such solution offering individualized voice: VocaliD™ [8] creates a unique synthesized BeSpoke™ [9] voice by combining

two speech signals: the residual vocalization of the individual seeking a customized voice, and the recordings of a matched-speech donor from VocaliD™'s Human Voicebank™ [10], a database comprised of over 17,000 speakers (see Figure 2). Patel asserted that a recording of a few seconds of vocalization, whether or not this is intelligible speech, could be enough to introduce the recipient's vocal identity cues into the matched voice to make it unique, while retaining the clarity and flexibility of the original.

Insert Figure 2 About Here

With reference to the first few users of VocaliD™'s personalized voices, Patel reported anecdotal evidence from clinicians who have baseline and post-voice delivery data on communication participation. Survey responses from recipients and family members provided insights into their perceptions of increased interest in social interaction and device use, greater autonomy of device use, and conversely a disinterest in using loaner devices with a generic voice if their primary device (i.e., with their new voice) needed to be serviced. Future controlled group studies are planned as the VocaliD™ customer base grows.

Exploring Expressive Voices

Another company, Cereproc™ [11], had previously developed a personalized voice for Roger Ebert, the film critic who lost the ability to speak following surgery (Ebert, 2012). Ebert's situation was unusual, in that hours of recordings of his voice already existed, stored in archives of his television shows, from which Cereproc recreated his vocal characteristics. Ebert, however, eventually abandoned this bespoke voice in favor of a generic voice that he considered to be more expressive. Whereas previously there was a stark choice between flexible but unconvincing parametric synthesis or realistic yet fixed and neutral corpus-based synthesis, Cereproc is

currently exploring the means to make changes, in real-time, to the intonation and prosody of synthetic speech, without compromising the intelligibility or realism.

During the Design Stream session, Pullin and Hennig introduced the pilot project Tonetable (Hennig & Pullin, 2016). Working with Cereproc (Aylett et al., 2016), they have built an early prototype of an interactive object--not a communication device, but a research tool to support participatory exploration of tone of voice: the variation in voice qualities employed by the same speaker, utterance by utterance, to convey attitude and intent. Tonetable allows researchers to play with expressive tones of voice with individuals who rely on AAC, in their homes and other social contexts. Pullin and Hennig's stated goal (Pullin & Hennig, 2015) is to use this apparatus to seed an international research network to explore the complexities of cultural differences with respect to tone of voice, as well as to create a clear direction and incentive for manufacturers to build this technology into future generations of AAC devices. Tonetable is an experience prototype (Buchenau & Fulton Suri, 2000)--part research apparatus, part board game as shown in Figure 3--to be actively explored and played with.

Insert Figure 3 About Here

The Complexity of Designing Voice

The more voice and tone of voice are explored in context, the less appropriate the sender-receiver model of communication embodied in such terms as speech-generating device and voice output communication aid appears to be. This is because tone of voice is employed not just to express the speaker's internal emotional state--a perspective that still dominates speech technology research and development (Pullin & Hennig, 2015)--but also to reflect, acknowledge, or actively frame the social relationship between conversational partners (Campbell, 2005; Hennig, 2013; Pullin, 2013). So if, and when, expressive tone of voice is made available to AAC

users, this will have complex implications for any conversation. This, in turn, implies a necessary degree of nuance of tone, lest users of AAC be inaccurately perceived as being socially incompetent (Alm & Newell, 1996).

Furthermore, the duality of a constant voice that represents one's identity and a variable tone of voice that expresses affect is simplistic. In practice, these two functions are intertwined. People typically adopt different voices (e.g., speech registers, nuances of accent, and other voice qualities) and different ranges of tone of voice in different company, contexts, and circumstances (Higginbotham, 2010; Izdebski, 2009). Between stable or lifelong voice qualities like regional accent or gender-related speech qualities and utterance-by-utterance intonation, we tune both our voice and our tone of voice conversation-by-conversation. Sometimes our tone of voice reflects the etiquette of the social context or the seriousness of the subject matter. Other times our tone of voice is responsive to the speech patterns and perceived identities of our conversational partners. Furthermore, our willingness to tune into a social context and our ability to express different social identities is itself a part of our own identity. In this way even voice, like conversation as a whole, is to a certain extent co-constructed.

In the case of VocaliD™, where individual identity is the focus, relatives and friends are also stakeholders and beneficiaries of a personalized voice. Patel reported instances of siblings and peers displaying greater empathy for the recipient using VocaliD™ . Do the relatives who found the generic voice to be jarring now find the person who uses AAC more engaging, or perceive her to be more capable? This of course feeds into the other two themes of the groups: designing for interaction and inclusion.

The issues of identity and expression embodied by voice are fundamental to the human experience, yet still relatively overlooked and underexplored within AAC research. The decision

to include voice in the Design Stream was a deliberate challenge to the prevalent assumption that creating synthetic voices is a scientific challenge, in that "speech technology is a multi-disciplinary field that occupies engineers, computer scientists and linguists" (Acero, 1995, p. 171). We proposed that voice-in-AAC is inseparable from other interactions and as such should be included in the notion of interaction design. And, being a research-led field, some of the research questions in these areas should be framed using appropriate design research methodologies. The exciting but daunting issue is that the field of AAC finds itself at the forefront of this development, perhaps because the need for voices that are both appropriate and expressive is so profound in our field (Alper, 2017).

Exploring Designing Inclusion

Including the Marginalized

The second author, Treviranus, introduced the term *inclusive design*, as it has evolved at the Inclusive Design Research Centre (IDRC[12]) that she founded and directs. Rather than designing for the typical, average, or mass-population, inclusive design takes the perspective of individuals who are marginalized: either through difficulty using a current design, or by a gap in available or accessible design solutions. Treviranus explained some nuanced distinctions between IDRC in Canada, inclusive design in the United Kingdom, and the field of accessibility. She proposed three dimensions of inclusive design as a defining framework: (a) recognizing individual difference and uniqueness, (b) including as many diverse perspectives in the design process as possible, and (c) recognizing the larger context and systemic impact of the design. Further drivers of digital inclusion are illustrated in Figure 4 (Treviranus, 2016).

Insert Figure 4 about here

At the edge or at the margins of any population there is far greater diversity. It can be

said that the only common characteristic of disability, for example, is difference (Wang, 2015). Because the dominant trend is to design for the average, typical, or mass audience, this difference causes a mismatch between the needs of each individual and the design of the environment, product, or service, affecting the experience of disability. Our dominant designs similarly exclude other individuals in a minority, whether the difference is language, culture, gender, age, background, or other aspect of human diversity. Anyone can find themselves at the edge and experiencing such a mismatch.

The very notion of an average human being is contested (Rose, 2015). And, while the term *big data* accentuates dominant patterns (Treviranus, 2014b), there is an emergent movement in fields such as medicine, policy, and education that recognizes the disparity caused by omitting the outliers (Merry Engle, 2016). Researchers are experimenting with "small" (personalized), "thick" (contextualized), and "edge" (outlying) data (Estrin, 2014, p. 32). Industry is acknowledging the complex, adaptive ecosystems that must be considered in any design (Jackson, 2006) even if academia can be more resistant to change (Treviranus, 2016).

Unlike other design approaches, the focus of inclusive design is to design *with* rather than *for* individuals or groups of people. The process grapples with the questions "Who is not included?", "Who is not participating in making design decisions?", and "Who will be indirectly excluded by this design?" Participants are included as co-designers in the idea generation, design decisions, evaluation, and iterative improvement stages of a design process. It has been shown that designing with people at the edges of a design domain stretches the design and leads to innovative leaps that improve the design for everyone (Jacobs, 2002). This applies to the design of policies, processes, products, governance models, infrastructures, and environments (Lewis & Treviranus, 2013). The margins of our society, which are currently systemically underserved and

ignored, represent an extremely rich pool of untapped skills, resources, resourcefulness, creativity, and motivation for change (Meyer & Rose, 2005, Treviranus, 2014a).

Inclusive Research Practice

Inclusive design is something the field of AAC signs up to, through the principle of "nothing about us without us" (Blackstone, Williams, & Wilkins, 2007, p. 193; Charlton, 1998), but what does this mean in practice? (Pullin 2015) Even participatory design is often still framed in terms of the participation of subjects, which perpetuates exclusion. Inclusive design intentionally blurs the distinctions between the designer and user, the consumer and producer, the learner and the educator, the expert and the non-expert, the service provider, and the client or customer. And pragmatically, given the paucity of resources devoted to addressing inclusive design and the large diversity of individuals excluded by current designs, inclusive design is compelled to be collaborative, open and transparent, rather than competitive and protective. Associated with this, in the context of a research symposium, various implications: methodological, ethical, socio-technical, economic, and professional, were explored.

The goal of the Tonetable project is participatory exploration between individuals who use AAC and speech-language therapists, with the challenge for it to be an inclusive, engaging activity and a credible research tool (Hennig & Pullin, 2016). Similarly, VocaliD™'s approach to creating a personalized voice includes not just the vocalization of the intended user but also their active participation, making choices as to the matched donor voice, and as such co-constructing a vocal identity that they feel is fitting. In all cases, inclusion will have socio-economic factors as well as those directly defined by disability (Alper, 2017).

The Complexity of Designing Inclusion

Diversity increases complexity. Inclusive design recognizes and supports diversity and its associated complexity, including a broad range of approaches and outcomes. Current evaluative measures, or criteria for evidence of impact, assume homogeneity and isolated conditions to support statistical significance and clean results (Treviranus, 2014b). Neither the outlying diverse beneficiaries of inclusive design nor inclusive design as a research field has the homogeneity needed to pass traditional thresholds used to evaluate impact and success. This has implications for scholars who require impact metrics to achieve tenure and promotion (Treviranus, 2016).

Maybe because of this inherent complexity, inclusive design draws on a landscape of different methodologies and methods, many of which are shared with interaction design. These include co-design, cultural probes, participatory design, edge personas, design ethnography, and experience prototyping (Buchenau & Fulton Suri, 2000; Gaver, Dunne, & Pacenti, 1999; Pullin, 2015; Pullin & Cook, 2010; Pullin & Gault, 2016). Many of these techniques can be described as exploratory, speculative, or even critical in that they do not seek to test or validate solutions, rather use design to illuminate and provoke new insights that might indirectly inform or inspire solutions in the future. The irony is that these techniques are often most valuable where issues are difficult to put into words and have not yet been articulated clearly. This may mean they are easier to justify in hindsight or on the basis of the debate they have catalyzed, than in advance, which has implications for attracting funding.

Discussions in the Design Stream

Issues around inclusive design and inclusive research practices were discussed with the Design Stream participants. There were concerns and insecurities among researchers as to how to reconcile appropriately inclusive research practices with the demands of their institutions and

funding bodies. These were considered to be important issues for the whole AAC research community. A number of further discussions arose--in some cases erupted--during the workshop, and three of these are explored in this section.

A Controversy About Technology

Several participants, including Scholte (personal communication, August 13, 2016), wished to challenge the assumed primacy of technological solutions such as speech-generating devices within AAC. This assumption had also been in the presenters' minds: Higginbotham, applied microanalysis to a diverse range of AAC interactions. Crampton Smith emphasized that interaction design "usually" involves digital technology (Crampton Smith & Tabor, 2007)--usually, not always: interaction design could be applied equally to paper-based AAC. Nonetheless this impression remained after the strands on designing interaction and in particular designing voice, with its emphasis on synthesized speech.

In response to this discussion, we shared a quotation often attributed to the performance artist Laurie Anderson: "Technology is the campfire around which we tell our stories" (McCorduck, 1994). By blurring the distinction between new and old technologies, we consider that this throws light on AAC in a number of ways. Far from being a neutral medium, any technology--fire, paper, or speech synthesis--becomes part of our experience of each other's stories, something that might positively frame a conversation, beyond managing not to inhibit a conversation. And so there is still much to learn about what can make paper-based AAC so appropriate, including its ability to be appropriated by both conversational partners. If better understood, some of these qualities could be brought into speech generating devices as well, or new hybrids might be conceived and crafted, combining paper-based, object-based, and/or digitally-based interactions (Hennig & Pullin, 2016; Moggridge, 2006).

In terms of research strategy, this requires that the field is prepared and able to make as strong a case as possible for the support of substantive innovative research across different media, independently of the technologies involved. This, in turn, would require a more informed and nuanced view of human-computer interaction studies and a more considered positioning of design-oriented research, viewing digital technology as just one of several modalities, and putting interaction first.

A Tension About Independence

Another issue to arise repeatedly in the symposium was that of independence. Look Howery (personal communication, August 13, 2016) noted her perception that the assumed goal of AAC was to foster independence in communication and proposed that interdependence in communication more appropriately represented AAC's highest goal, an argument supported by most of the participants. The presenters had not consciously set this perception: Higginbotham's analysis of interactions had stressed the interdependence of communicators. On reflection, the issue may be that independence need not be at the expense of interdependence, whereas perhaps the former currently dominates the latter in AAC research. The identification of this issue illuminated a thread running through all three strands of the Design Stream, (a) in terms of interaction, the notion of interdependence challenges the send–receiver model of communication by acknowledging the presence of co-creation in all communication; (b) in terms of voice, interdependence promotes the idea of the shared construction and even ownership of identity; and (c) in terms of inclusive design, interdependence is at the core of innovation and empowerment.

A Provocation About Taste

Darryl Sellwood, a researcher and person who uses AAC, was an active participant throughout the Design Stream, contributing his experiences and reflections. He also gave a presentation of his own project, the Bummunicator (Sellwood, 2015). The Bummunicator is a video screen on the back of a wheelchair that displays an image of the (clothed) behind of the person in the wheelchair. This bodily visibility may be taken for granted in walking people--and indeed wheelchair users may be even more aware of it, given their seated height--yet wheelchair users are denied this form of body communication. Social interaction between individuals can include passing by, or looking without talking.

Positioning the Bummunicator in terms of art-school interaction design methodology, it can be seen as a piece of critical design, even though that is not how Sellwood himself introduced it. Critical design often engages its audience using dark humor with serious intent, and the screening of Sellwood's video about the Bummunicator provoked sometimes-awkward laughter followed by discussion. Yet far from being just a joke, Bummunicator invited reflection on issues of disability, sexuality, and the right to define one's own borders of taste and conduct. It represents a notion of voice beyond speech, to include body language, clothing, and identity. This embodied a wider discussion of voice in the Design Stream. Moreover, research about AAC, by people who use AAC, is part of inclusive research practices.

New Directions for AAC Research

The Inseparability of Interaction, Voice, and Inclusion

The Design Stream discussions cut across and interwove interaction, voice, and inclusion rather than fitted neatly under one or another. The connections that they made illustrate the

inseparability of the three strands. Therefore, our directions for future research also cut across these three strands, and each illuminates the others.

Toward New Interdisciplinary AAC Research

AAC research could offer new perspectives on the detailed interactions between conversational partners, which is why methods such as microanalysis can be so illuminating. At the same time, AAC research makes little use of the entire discipline of interaction design, the art school discipline that has done so much to weave what was previously thought of as computing into the fabric of our everyday lives. If we are to harness both of these necessary perspectives together, AAC research will need to become more interdisciplinary, finding ways to combine methodologies as complementary but culturally distant as microanalysis and interaction design. As Scholte (personal communication, August 14, 2016) and other participants in the Design Stream, noted, however, if anything, AAC as a field has become more "monochromatic" as it matures from its interdisciplinary roots into an established field of research. Disciplinary change is not a trivial undertaking: it will involve bridging academic research cultures, addressing practice-based interdisciplinary challenges, and unlocking funding for methodologically unconventional modes of inquiry. We propose that AAC research might better explore what it would mean to design for the quality and qualities of interaction. Such a shift in perspective might be what is required to break genuinely new ground--something that has been called for in the field of AAC many times, over many years (Newell, 1992; Portnuff, 2006), but which has yet to materialize.

Toward New AAC Research Tools

The field of AAC now finds itself at the frontiers of speech technology research and development, not just the recipient of developments in more mainstream fields. This is at once an

opportunity and a challenge. If AAC research were to venture into a middle ground between voice and tone of voice it would be venturing into what is subtle and nebulous territory for any field. A broader notion of a machine voice tuning into a human voice has a role in mainstream applications such as virtual assistants, interactive voice response, and even social robotics to enhance empathy and interaction. AAC perspectives could play a significant role in the design of speech technology, which is often not seen as a designed medium at all.

If the qualities of voice are not wholly determined by the individual but somehow co-constructed socially (i.e., so that our conversational partners not only interpret our voices, but also influence them) then this implies that AAC research should be conducted with multiple participants in social settings, rather than with subjects in carefully controlled laboratories. For both of these reasons, we may need new research tools as apparatus for engaging, accessible, and contextual participatory research; and to develop these ourselves.

Toward New Open AAC Research Networks

Fully inclusive research implies not just the participation of people who use AAC but also their shared ownership of this research. This suggests an open model that itself may need to be reconciled with an increasing emphasis on intellectual property in the academic and commercial sectors. Embracing the inherent complexities of inclusive design will require international, interdisciplinary, interdependent research networks as never before.

References

Acero, A. (1995). The role of phoneticians in speech technology. In G. Bloothooft, V. Hazan, D. Huber, & J. Llisterri (Eds.), *European studies in phonetics and speech communication* (pp. 170–175). Utrecht, Netherlands: OTS.

Alm, N., & Newell, A. (1996). Being an interesting conversation partner. In S. von Tetzchner & M. H. Jensen (Eds.), *Augmentative and alternative communication: European perspectives* (pp. 171–181). London, UK: Whurr.

Alper, M. (2017). *Giving voice: Mobile communication, disability, and inequality.* Cambridge, MA: The MIT Press.

Aylett, M., Potard, B., Pullin, G., Hennig, S., Braude, D., & Ferreira, M. (2016). Don't say yes, say yes: Interacting with synthetic speech using Tonetable. *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 3643–3646). New York, NY: ACM. doi:10.1145/2851581.2890245

Blackstone, S., Williams, M., & Wilkins, D. (2007). Key principles underlying research and practice in AAC. *Augmentative and Alternative Communication, 23,* 191–203. doi:10.1080/07434610701553684

Buchenau, M., & Fulton Suri, J. (2000). Experience prototyping. *Proceedings of the 3rd Conference on Designing Interactive Systems (DIS): Processes, practices, methods, and techniques* (pp. 424–433). New York, NY: ACM.

Campbell, N. (2005). Getting to the heart of the matter: Speech as the expression of affect, rather than just text or language. *Language Resources & Evaluation, 39,* 109–118. doi:10.1007/s10579-005-2699-y

Charlton, J. (1998). *Nothing about us without us: Disability oppression and empowerment*. Berkeley, CA: University of California Press.

Clark, H. H. (1996). *Using language*. Cambridge, UK: Cambridge University Press.

Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. In L. B. Resnick, J. M. Levine, & S.D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 127–149). Washington, DC: American Psychological Association.

Clarke, M., & Bloch, S. (2013). AAC practices in everyday interaction. *Augmentative and Alternative Communication, 29,* 1–2. doi:10.3109/07434618.2013.767487

Cook, A. (2013). *Studying interaction design by designing interactions with tone of voice.* (Unpublished doctoral dissertation). University of Dundee, Dundee, UK.

Crampton Smith, G., & Tabor, P. (2007). *Interaction design*. Retrieved from http://www.interaction-venice.com

Dunne, A., & Raby, F. (2001). *Design noir: The secret life of electronic objects*. Basel, Switzerland: Birkhäuser.

Ebert, R. (2012). *Life itself: A memoir*. New York, NY: Grand Central.

Engelke, C. R. (2013). *Technically speaking: On the structure and experience of interaction involving augmentative alternative communications* (Doctoral dissertation). University of California, Los Angeles, CA. Retrieved from http://escholarship.org/uc/item/7vh6c65h

Estrin, D. (2014). Small data, where n= me. *Communications of the ACM, 57,* 32–34. New York, NY: ACM. doi:10.1145/2580944

Frayling, C. (1994). Research in Art and Design (Royal College of Art Research Papers, Vol 1, No 1, 1993/4). Retrieved from: http://researchonline.rca.ac.uk/id/eprint/384

Gaver, W., Dunne, A., & Pacenti, E. (1999). Cultural probes. *Interactions, 6,* 21–29. doi:10.1145/291224.291235

Goodwin, C. (1979). The interactive construction of a sentence in natural conversation. In G. Psathas (Ed.), *Everyday language: Studies in ethnomethodology* (pp. 97–121). New York, NY: Irvington Publishers.

Goodwin, C. (2003). The semiotic body in its environment. In J. Coupland and R. Gwyn (Eds.), *Discourses of the body* (pp. 19–42). New York, NY: Palgrave/Macmillan.

Goodwin, C. (2007). Participation, stance and affect in the organization of activities. *Discourse & Society, 18,* 53–73. doi:10.1177/0957926507069457

Hennig, S. (2013). *Candidacy of biosignals as an implicit input method for expressive speech synthesis* (Unpublished doctoral dissertation). Italian Institute of Technology, Genoa, Italy.

Hennig, S., & Pullin, G. (2016, August). *Tonetable--starting a hands on conversation about tone of voice in AAC*. Paper presented at the International Society for Augmentative and Alternative Communication 17th biennial conference, Toronto, Canada.

Higginbotham, D. J. (2010). Humanizing vox artificialis: The role of speech synthesis in augmentative and alternative communication. In J. W. Mullennix & S. E. Stern (Eds.), *Computer synthesized speech technologies: Tools for aiding impairment* (pp. 50–69). Hershey, PA: IGI Global. doi:10.4018/978-1-61520-725-1

Higginbotham, D. J., & Caves, K. (2002). AAC performance and usability issues: the effect of AAC technology on the communicative process. *Assistive Technology, 14*, 45–57. doi:10.1080/10400435.2002.10132054

Higginbotham, D. J., & Engelke, C. R. (2013). A primer for doing talk-in-interaction research in augmentative and alternative communication. *Augmentative and Alternative Communication, 29,* 3–19. doi:10.3109/07434618.2013.767556

Higginbotham, D. J., Fulcher, K., & Seale, J. (2016). Time and timing in interactions involving individuals with ALS, their unimpaired partners and their speech generating devices. In M. M. Smith, & J. Murray (Eds.), *The silent partner? Language, interaction and aided communication*. Guildford, UK: J & R Press.

Higginbotham, D. J., & Wilkins, D. P. (1999). Slipping through the timestream: Social issues of time and timing in augmented interactions. In D. Kovarsky, M. Maxwell, & J. Duchan (Eds.), *Constructing (in)competence: Disabling evaluations in clinical and social interaction* (pp. 49–82). Mahwah, NJ: Lawrence Erlbaum.

Jackson, M. C. (2006). Creative holism: A critical systems approach to complex problem situations. *Systems Research, 23*, 647–657. doi:10.1002/sres.799

Jacobs, S., (2002). *The electronic curb-cut effect*. Developed in support of the World Bank Conference on Disability and Development. Retrieved from http://www.icdri.org/technology/ecceff.htm

IDEO (2001). *Social mobiles*. Retrieved from http://p-lin-app-df-01.ideo.com/work/social-mobiles/

Izdebski, K. (Ed.) (2009*). Emotions in the human voice* [Vol 1–3]. San Diego, CA: Plural.

Lewis, L., & Treviranus, J. (2013) Public policy and the global public inclusive infrastructure project. *Interactions, 20,* 62-66. doi:10.1145/2510123

Martin, B., & Hanington, B. (2012). *Universal methods of design*. Beverly, MA: Rockport.

Merry Engle, S. (2016). *The seductions of quantification: Measuring human rights, gender violence, and sex trafficking*. Chicago, IL: University of Chicago Press.

Meyer, A., & Rose, D. H. (2005). The future is in the margins: The role of technology and disability in educational reform. In D. H. Rose, A. Meyer, & C. Hitchcock (Eds.), *The universally designed classroom: Accessible curriculum and digital technologies* (pp. 13–35). Cambridge, MA: Harvard Education Press.

McCorduck, P. (1994). America's multi-mediatrix. *Wired*. Retrieved from https://www.wired.com/1994/03/anderson/

McGettigan, C. (2015). The social life of voices: Studying the neural bases for the expression and perception of the self and others during spoken communication. *Frontiers in Human Neuroscience, 9*, 1–4. doi:10.3389/fnhum.2015.00129

Mills, T., Bunnell, T. H., & Patel, R. (2014). Towards personalized speech synthesis for assistive communication. *Augmentative and Alternative Communication, 30*, 226–236. doi:10.3109/07434618.2014.924026

Moggridge, B. (2006). *Designing interactions*. Cambridge, MA: The MIT Press.

Monk, A. (2008). Common ground in electronically mediated conversation. *Synthesis Lectures on Human-Centered Informatics, 1,* 1–50. doi:10.2200/S00154ED1V01Y200810HCI001

Newell, A. (1992). Today's dream–tomorrow's reality (Phonic Ear AAC Distinguished Lecture). *Augmentative and Alternative Communication, 8,* 1–8. doi:10.1080/07434619212331276113

Newell, C. [Producer], & Ridley, L. [Writer]. (2012). *Voice by choice* [Motion Picture]. United Kingdom: University of York, Department of Theatre Film and Television. Retrieved from http://vimeo.com/46831064

Ochs, E. (1979). Transcription as theory. In E. Ochs, & B. Schieffelin (Eds.), *Developmental pragmatics* (pp. 43–72). New York, NY: Academic Press.

Ochs, E., Graesch, A. P., Mittman, A., Bradbury, T., & Repetti, R. (2005). Video ethnography and ethnoarchaeological tracking. In M. Pitt-Catsouphes, E. E. Kossek, & S. Sweet (Eds.), *The work and family handbook: Multi-disciplinary perspectives and approaches* (pp. 387–409). Mahwah, NJ: Lawrence Erlbaum.

Patel, R., & Threats, T. (2016). One's voice: A central component of personal factors in augmentative and alternative communication. *Perspectives of the ASHA Special Interest Groups SIG 12,* 94–98.

Portnuff, C. (2006, August). *Augmentative and alternative communication: A user's perspective*. Lecture delivered at the Oregon Health and Science University. Retrieved from http://aac-rerc.psu.edu/index-8121.php.html

Pullin, G. (2009). *Design meets disability*. Cambridge, MA: The MIT Press.

Pullin, G. (2013). *17 ways to say yes, exploring nuanced tone of voice in augmentative communication and designing new interactions with speech synthesis* (Doctoral dissertation). University of Dundee, Dundee, UK.

Pullin, G. (2015). Participatory design and the open source voice. In D. Barney, G. Coleman, C. Ross, J. Sterne, & T. Tembeck (Eds.), *The participatory condition in the digital age* (pp. 101–122). Minneapolis, MN: University of Minnesota Press.

Pullin, G., & Cook, A. (2010). Six speaking chairs (not directly) for people who cannot speak. *Interactions, 17,* 38–42. doi:10.1145/1836216.1836226

Pullin, G., & Gault, P. (2016, August). *Imaginative and creative participatory research in AAC.* Paper presented at the International Society for Augmentative and Alternative Communication 17th biennial conference, Toronto, Canada.

Pullin, G., & Hennig, S. (2015). 17 ways to say yes: Toward nuanced tone of voice in AAC and speech technology. *Augmentative and Alternative Communication 31,* 170–180. doi:10.3109/07434618.2015.1037930

Robillard, A. (2006). Paralysis. In G. Albrecht (Ed.), *Encyclopedia of disability* (pp. 1197–1201). Thousand Oaks, CA: Sage Publications.

Robillard, A. B. (1999). *Meaning of a disability: The lived experience of paralysis*. Philadelphia, IL: Temple University Press.

Rose, T. (2015). *The end of average: How we succeed in a world that values sameness*. New York, NY: HarperOne.

Sellwood, D. (2015). *Bummunicator*. Retrieved from http://darrylsellwood.com

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell System Technical Journal, 27,* 379–423. doi:10.1145/584091.584093

Treviranus, J. (2014a). Leveraging the web as a platform for economic inclusion. *Behavioral Sciences and the Law, 32,* 94–103. doi:10.1002/bsl.2105

Treviranus, J. (2014b). The value of the statistically insignificant. *EDUCAUSE Review, 49*(1), 46-47. Retrieved from https://er.educause.edu/articles/2014/1/the-value-of-the-statistically-insignificant

Treviranus, J. (2016). Life-long learning on the inclusive web. *Proceedings of the 13th Web for All Conference*, Article 1. doi:10.1145/2899475.2899476

Wang, M. [Director]. (2015). *Inclusive* [Motion Picture]. United States: Microsoft Design in partnership with Cinelan. Retrieved from www.inclusivethefilm.com

Wilkinson, R., Bloch, S., & Clarke, M. (2011). On the use of graphic resources in interaction by people with communication disorders. In J. Streeck, C. Goodwin, & C. LeBaron (Eds.), *Embodied interaction: Language and body in the material world* (pp. 152–168). Cambridge, UK: Cambridge University Press.

End Notes

[1] InqScribe™ is a transcription software application from Inquirium™, Chicago, IL. http://docs.inqscribe.com/2.2/

[3] Lightwriter™ is an AAC device manufactured by Abilia Toby Churchill™ Ltd. www.toby-churchill.com

[4] InterAACt™ is an AAC language framework used on DynaVox™ devices manufactured by TobiiDynaVox™ Inc. www.dynavoxtech.com/interaact/

[2] Tango!™ was an AAC device developed by Richard Ellenson and BlinkTwice™ Inc. It is no longer being manufactured.

[5] Nuance™ is a company in Burlington, MA that produces speech recognition and speech synthesis products. www.nuance.com

[6] Acapela™ is a European company in Mons, Belgium, Labège, France; and Solna, Sweden that develops text-to-speech software and services. www.acapela-group.com

[7] The iPad™ is a product of Apple™ Inc., Cupertino, CA. www.apple.com

[8] VocaliD™ is a company in Belmont, MA concerned with the preservation, restoration, and creation of vocal identities. www.vocalid.co

[9] BeSpoke™ is a personalized voice service from VocaliD™. https://www.vocalid.co/bespoke

[10] The Human Voicebank™ is a resource of VocaliD™. www.vocalid.co/voicebank#

[11] Cereproc™ is a Scottish company in Edinburgh, UK that conducts speech synthesis research and produces advanced text to speech technology. www.cereproc.com

[12] IDRC is the Inclusive Design Research Centre at OCAD University, Toronto, Canada. http://idrc.ocadu.ca

Figure Captions

Figure 1: A microanalysis transcription interface using InqScribe™ [1] (Higginbotham & Engelke, 2013). The recording and frame-by-frame replay of video from multiple cameras is combined with a time-coded transcription of utterances and other interactions.

Figure 2: Schematic of VocaliD's BeSpoke™ [9] voice creation process. A short recording of vocalization by the voice recipient is combined with a recorded corpus from a matched voice donor, to create a personalized yet comprehensive synthetic voice.

Figure 3. Tonetable cards annotated at CHI 2016 (Aylett et al., 2016). Each blank card is an abstract representation of a different tone of voice, until given meaning by participants. The latest prototype uses physical tokens in place of cards, to be more inclusive.

Figure 4: Virtuous cycles of digital inclusion from the IDRC[12]. The three rings illustrate the impact of greater access to and inclusive participation in the design process and the mutual effects of action at the level of the individual, society, and system.